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Laboratory Test Report for ThermaStor Ultra-Aire XT150H Dehumidifier

Dane Christensen and Jon Winkler

Technical Report
NREL/TP-550-47215
December 2009

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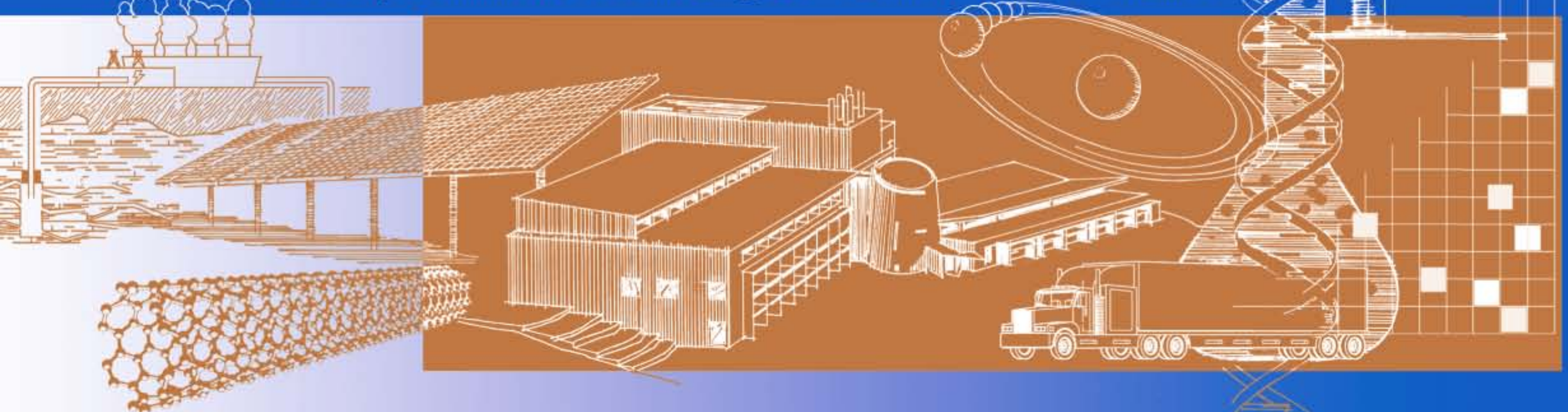

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National Renewable Energy Laboratory
1617 Cole Boulevard, Golden, Colorado 80401-3393
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Abstract

This report documents the measured performance of the ThermaStor Ultra-Aire XT150H Dehumidifier. The equipment is an ENERGY STAR® vapor-compression cycle whole-house unit. Its performance was measured across a wide range of inlet air conditions and fit to a numerical model with R-squared values greater than 0.998 for electrical power consumption, sensible and latent load removal. The numerical fit was then used to implement the Zone Air Direct-Expansion (DX) Dehumidifier performance model in EnergyPlus.

The authors would like to acknowledge Jeff Tomerlin of NREL for his assistance with data collection.

Acronyms

AHAM	American Home Appliance Manufacturers
ANSI	American National Standards Institute
CFM	cubic feet per minute
DB	dry bulb
DX	direct expansion
HVAC	heating, ventilating, and air conditioning
RH	relative humidity
SCFM	standard cubic feet per minute

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Overview

The ThermaStor Ultra-Aire XT150H Dehumidifier is designed as an efficient vapor-compression cycle whole-house unit. It can be used as a stand-alone system with unique ductwork or can be incorporated into an HVAC system. It has an outdoor air inlet for optional use in dehumidifying ventilation air. The equipment was EnergyStar rated, with the best rated performance among the residential EnergyStar dehumidifiers, at the time of testing. Manufacturer Specifications from the Owner's Manual are shown in Figure 1. A depiction from the Owner's Manual of a standard installation is shown in Figure 2. Figure 3 shows a functional schematic of the refrigerant loop, air flow and condensate removal.

2. Specifications

Model:	Ultra-Aire XT150H Indoor Air Quality System
Electrical:	110-120 VAC, 6.9 Amps, 60 Hz, grounded
Water Removal Capacity:	150 pints/day @ 80°F, 60% RH
Operating Temp. Range:	56°F min., 100°F max.
Air Flow:	415 CFM @ 0.0" WG 365 @ 0.4" WG
Refrigerant Charge:	2 lb., R-410.A
Duct connections: (ovaled)	Round 10" & 6" inlets, 10" outlet
Filter Size:	2" X 16" X 16"
Size (w/o duct collars):	37" wide X 22" high X 20 5/8" deep
Unit Weight:	134 lbs.

Figure 1. XT150H technical specifications [1]

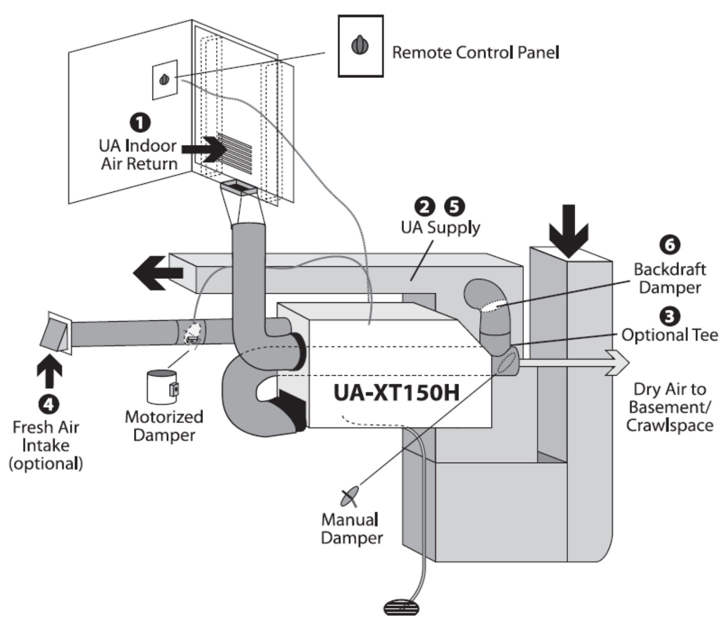


Figure 2. XT150H typical installation [1]

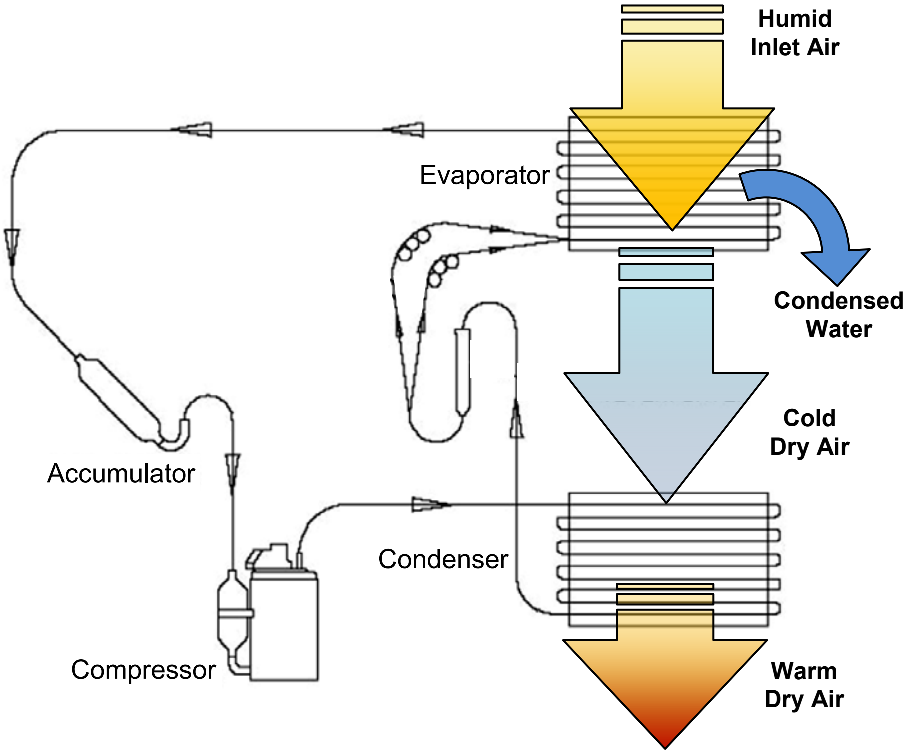


Figure 3. XT150H process schematic. An intermediate air-to-air heat exchanger, which spans the evaporator, is not shown.

Test Description

A Thermastor Ultra-Aire XT150H dehumidifier was tested at the National Renewable Energy Laboratory in the Thermal Transfer Lab with funding from DOE for the Building America program. The method of test followed ANSI/AHAM DH-1-2003, except as listed below. Air was supplied at tightly controlled psychrometric states and the performance was measured over a period of up to 50 minutes at each of 12 test conditions. These test conditions were chosen to represent some typical operating conditions, as well as to bracket those conditions for more accurate interpolation modeling. A summary of the test data is presented in Appendix A.

Inlet and outlet air flow rates were measured using laminar flow elements. An initial set of tests showed that the unit's fan drew 330 CFM at zero external static pressure drop. For subsequent tests, air flow was maintained by the lab's inlet fan to provide appropriate mass flow to the dehumidifier's return duct. Unit pressure was controlled to ambient pressure by the lab's outlet fan, to minimize potential errors from small air leaks. Air Mass Balance was defined as the ratio of instantaneous inlet air mass flow rate to instantaneous outlet air mass flow rate.

Dew point was monitored on both inlet and outlet airstreams using chilled mirror hygrometers, providing a precise measure of air humidity. Condensate flow rate was measured using a coriolis flowmeter. Condensate was also collected in a container and weighed after each test run, in accordance with ANSI/AHAM DH-1-2003. These results were recorded but not used in the ensuing analysis, for two reasons. First, condensate collection provides average condensate production rather than instantaneous. Secondly, to obtain similar accuracies to the coriolis flowmeter's, test runs needed to be quite lengthy. Use of a coriolis flowmeter allowed test times of minutes, not hours. A Moisture Mass Balance was defined as the ratio of instantaneous inlet air moisture mass flow rate to the sum of outlet air moisture mass flow rate and condensate flow rate.

Temperatures of the well-mixed inlet and outlet airstreams were measured using a thermocouple array within ductwork near the unit. Inlet and outlet static pressure were measured using pitot tubes near the unit. Enthalpy was calculated for the airstreams using ASHRAE standard formulas. Electric power was measured using a power meter. An Energy Balance was defined as the ratio of the sum of inlet air energy rate and electric power to the sum of outlet air energy and condensate energy rates.

Photos of the experimental setup are shown in Appendix B.

Instantaneous Air Mass and Energy Balances in all cases were achieved to within 0.5% and 1.6%, respectively. Instantaneous Moisture Balance was not met as closely due to moisture retention within the unit and piping systems caused by condensate surface tension, but still fell within 5%. A summary of these balances is provided in Table 1.

Table 1. Summary of Measured Parameter Balances

	Average	Minimum	Maximum	Standard Deviation
Energy Balance	0.998	0.984	1.005	0.006
Air Mass Balance	1.000	0.995	1.004	0.003
Moisture Mass Balance	1.015	0.984	1.047	0.025

Results

The experimental data was fit to a biquadratic equation. This is a typical form used to model HVAC equipment. However, in the case of a packaged dehumidifier the dry bulb and dew point temperatures of significance both refer to the dehumidifier inlet air. (Typical parameters of significance for unitary air conditioners are: indoor air dew point and outdoor air dry bulb temperature.) Six performance parameters were investigated for applicability of the model. The performance curve, a function of inlet dry bulb temperature (°C) and inlet dew point temperature (°C), is:

$$\boldsymbol{Parameter = A \times T_{DB} + B \times T_{DB}{}^2 + C \times T_{Dew} + D \times T_{Dew}{}^2 + E \times T_{DB} \times T_{Dew} + F} \qquad (1)$$

Curve fit coefficients are shown in Table 2. Electric Power Consumption includes fan power at 0" water static pressure across the packaged unit. Since the outlet air has a higher temperature than the inlet air, Sensible Load Removal is seen to be negative at all times. The equations for Latent and Sensible Load Removal may be summed to achieve a Total Load Removal equation, the coefficients of which are shown below for convenience. (Note that "Sensible Load Removed" and "Total Load Removed" have a negative value at all operating conditions, since the outlet air is warmer than inlet air by the latent heat removed plus electric power consumed.) Further, the efficiency metrics of condensate production in pints/day and liters/kWh were fit to the same form with good correlation. This will allow efficiency comparison of dehumidifiers at conditions away from the ANSI/AHAM DH-1-2003 test point: 80ºF dry bulb, 69.6ºF wet bulb (64.55ºF dew point, 59.8% RH).

Table 2. Curve Fit Coefficients and Coefficient of Determination for Measured Effects of the Ultra-Aire XT150H Dehumidifier

Parameter: Coefficient	Electric Power Consumption (kW)	Total Load Removed (kW)	Sensible Load Removed (kW)	Latent Load Removed (kW)	Estimated Production (pints/day)	Efficiency (L/kWh)
A	0.000647	0.0340	0.0631	–0.0290	–1.21	–0.0845
B	0.000143	–0.000675	–0.000473	–0.000202	–0.0244	8.32E-5
C	0.00343	–0.0254	–0.166	0.140	7.87	0.279
D	0.000212	–0.000407	–0.000997	0.000589	0.0715	–0.00158
E	1.868E-5	0.000773	0.00171	–0.000935	–0.0330	–0.00169
F	0.567	–1.05	–1.79	0.741	49.8	2.059
r-squared	0.998	0.987	0.999	0.999	0.998	0.998

Plots of these curves and comparisons of model results to the measured data are presented in Appendix C. With R-Squared values (shown above) demonstrating close agreement of the model with measured performance, these curves are sufficient to simulate the performance of the equipment in annual simulations under full-load conditions. Cycling measurements are needed to complete the unit's model for part-load conditions.

Version 4.0.0 of EnergyPlus, an annual whole building simulation tool, includes a zone dehumidifier component model for the first time [2]. The component model simulates the thermal performance and electric power of a conventional DX dehumidifier. Performance curves are used to scale the rating point performance to simulate various operating conditions. The rating point performance was determined using test point 13a, as shown in Appendix A. Performance curves are used to predict the water removal rate (L/day) and energy factor (L/kWh) fractions and should be approximately equal to a value of 1 at the rated operating condition. The performance curve implemented by the EnergyPlus model, a function of inlet dry bulb temperature (°C) and inlet relative humidity (0-100%), is:

$$\boldsymbol{Parameter = A + B \times T_{DB} + C \times T_{DB}^{2} + D \times RH + E \times (RH)^{2} + F \times T_{DB} \times RH} \quad (2)$$

The model uses a cubic function to predict the part load fraction as a function of the part load ratio. The part load fraction performance curve coefficients recommended in the EnergyPlus documentation were used since part load performance was not measured during the experimental testing.

The performance curve fit coefficients are shown in Table 3. The R-squared values indicate the performance curves have accurately captured the experimental performance.

Table 3: Curve Fit Coefficients and Coefficient of Determination for EnergyPlus Performance Curves for the Ultra-Aire XT150H Dehumidifier

Parameter: Coefficient	Water Removal Rate Fraction	Energy Factor Fraction
A	–1.281357458	–2.743752887
B	0.032064893	0.114491512
C	–0.000280794	–0.001456831
D	0.028356002	0.053860412
E	–0.000134939	–0.000244965
F	0.000271496	–0.000362021
r-squared	0.998	0.989

Appendix D contains plots displaying the accuracy of the model. The average relative error in the water removal rate is 1.4% with a maximum error of 3.74% and the average relative error in the energy factor is 2.67% with a maximum error of 7.46%.

Other Observations

The manufacturer's specifications were confirmed except for one. The Unit Under Test did not provide air flow at the rated 415 CFM at 0 in.H2O static pressure. Instead, 325-335 CFM was measured when the unit was presented with no pressure drop. Since an installed unit's pressure drop is installation-specific, it is not possible to include the effect of other differential pressure conditions in an annual simulation. However, the low volumetric flow rate combined with large duct sizes that would typically be used in homes requiring this dehumidifier implies that assuming a low pressure drop is not unreasonable.

Discussion and Conclusions

The ThermaStor Ultra-Aire XT150H Dehumidifier achieved its rated performance at test conditions. A numerical model was used to fit the experimental data within a small error. Therefore, it is assumed that the model is a reasonable representation of the unit and may be used in annual energy simulations.

It is clear from the plots in Appendix C that unit performance is maximized at high inlet air dew point, regardless of dry bulb temperature. It is easier for the unit to bring the evaporator coil's temperature below the dew point in those cases. At a given dew point, lower dry bulb temperatures lead to higher efficiency for the same reason – less sensible cooling is needed to bring the air to 100% relative humidity.

The dehumidifier operates by returning the heat of vaporization, which is absorbed into the refrigerant as the water condenses out of the air, back to the airstream in the form of sensible heat. The more moisture that is removed, the more sensible heat must be rejected downstream. This reheat process is ideally a balanced enthalpy exchange. However, the dehumidifier also heats the outlet air via the fan motor and compressor power. As a result, the outlet air enthalpy is increased in direct proportion to the unit's power consumption. The unit will always apply a positive sensible load in excess of the latent load removal.

The ducted outlet of the unit was extremely warm, and extra insulation had to be applied to restrict heat loss and achieve proper energy balance. This high temperature is demonstrated by the high sensible heat load (large negative sensible heat removal) from the model. Within the expected temperature range of this unit's residential usage, it is seen that the sensible load applied to the house is between 2.0 and 3.5 kW. In a home with typical loads, the central cooling system would provide sufficient dehumidification during peak periods, thus this sensible load poses little concern. It is advisable for an HVAC designer to consider the sensible heat impact of a dehumidifier on occupant comfort, particularly during shoulder seasons when the air conditioner operates in part load.

There may be opportunities for improvement in efficiency through design modifications, pending future work including inspection and analysis of the inner systems. This has not been initiated because of the desire to test cycling behavior of the unit, which will require modifications to the laboratory apparatus and adjustment of testing protocols. That work is ongoing. The controls of the dehumidifier will play a role in the thermal cycling performance and condensate re-evaporation. These effects are not yet included in the model.

References

[1] Ultra-Aire XT150H Installer's & Owner's Manual. Available at: http://www.ultra-aire.com/images/pdfs/UA-XT150H_manual.pdf. Accessed 5/15/2008.

[2] EnergyPlus is a DOE-sponsored simulation program, freely available at http://apps1.eere.energy.gov/buildings/energyplus/. Version 4.0.0 was used for this work.

Appendix A – Summary of Measured and Calculated Test Data

The data points used for testing are shown on a psychrometric chart in Figure 4. Psychrometric chart showing test points. A summary table of results is presented below in Table 4 and Table 5.

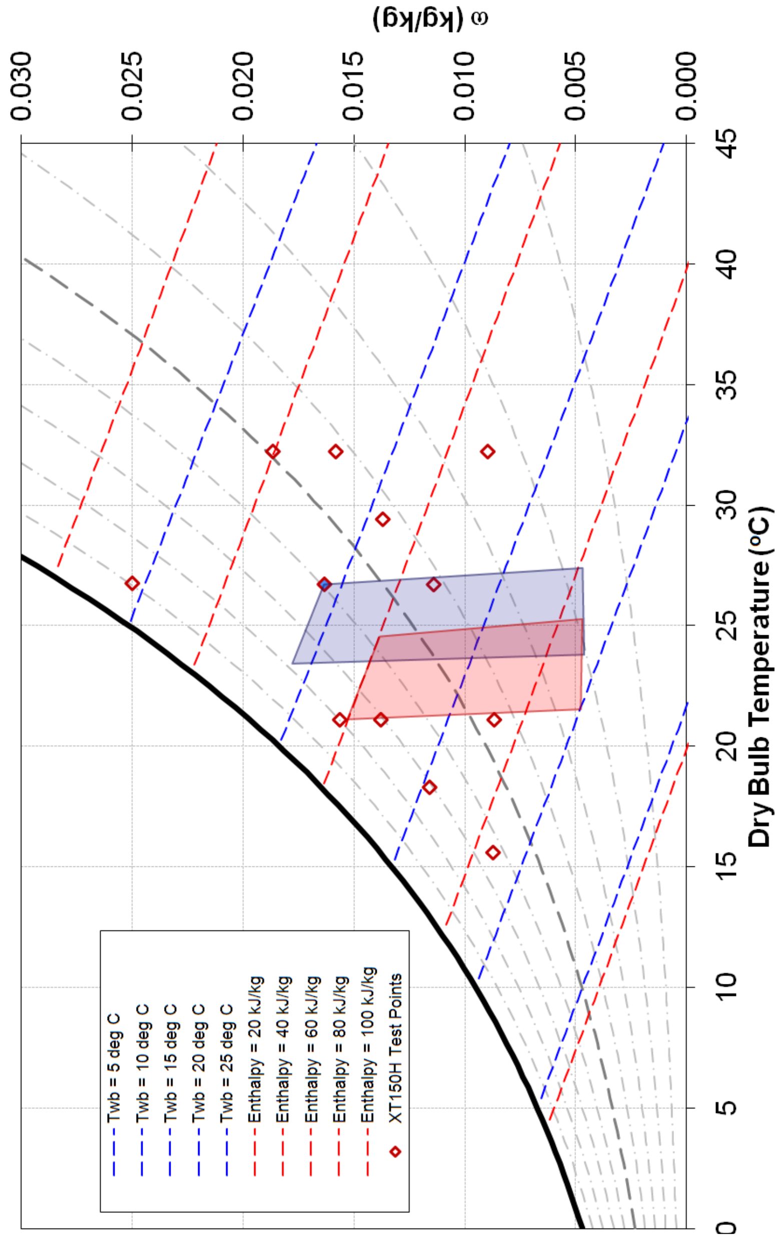


Figure 4. Psychrometric chart showing test points. ASHRAE thermal comfort regions are shaded in blue (cooling) and red (heating).

Table 4. Summary of Test Data

		Unit	10a	5a	11a	12a	6a	7a
	Test Duration	Hours	0.518	0.800	0.540	0.549	0.581	0.580
	T_In	deg_C	15.60	21.10	32.20	18.30	26.70	21.10
	T_Out	deg_C	27.29	31.07	39.29	32.34	37.75	36.53
	T_condensate	deg_C	4.09	5.83	10.36	8.21	9.85	10.32
	Tdew_In	deg_C	8.79	8.66	9.19	12.99	12.70	15.56
	Tdew_Out	deg_C	2.33	3.75	7.00	6.56	8.28	9.37
	W_In	kg/kg	8.75E-03	8.69E-03	8.99E-03	1.16E-02	1.14E-02	1.38E-02
	W_Out	kg/kg	5.56E-03	6.17E-03	7.73E-03	7.49E-03	8.47E-03	9.12E-03
	W_In	grains	61.24	60.86	62.91	81.25	79.95	96.62
	W_Out	grains	38.90	43.17	54.11	52.42	59.26	63.84
	Delta_grains	grains	22.34	17.69	8.80	28.82	20.69	32.77
	P_ambient	Pa	81614	81361	81639	81705	81442	81428
	P_In	Pa	81612	81360	81637	81703	81441	81428
	P_Out	Pa	81615	81376	81641	81707	81443	81427
	Air flow_In	SCFM	327.9	325.1	326.1	328.3	329.7	328.4
	Air flow_Out	SCFM	329.4	326.0	327.1	327.6	328.4	327.8
	Flow_Condensate (Coriolis)	kg/s	5.29E-04	4.40E-04	3.02E-04	6.74E-04	5.39E-04	7.85E-04
	Flow_Condensate (Coriolis)	gpm	8.39E-03	6.98E-03	4.79E-03	1.07E-02	8.55E-03	1.25E-02
	Total Condensate Weight (Scale)	lb	2.13	2.81	1.13	3.06	2.50	3.75
	Total Condensate Weight (Coriolis)	lb	2.180	2.805	1.297	2.944	2.494	3.625
	Total Condensate Weight (Coriolis)	kg	0.989	1.272	0.588	1.335	1.131	1.644
	Balance_AirMass	Unitless	0.995	0.997	0.997	1.002	1.004	1.002
	Balance_MoistureMass	Unitless	1.038	1.015	0.958	1.047	1.010	1.037
	Balance_Energy	Unitless	0.984	0.994	0.997	0.995	1.004	0.998
	Electric Power	kW	0.659	0.698	0.792	0.708	0.763	0.756
	Total Load Removal	kW	–0.707	–0.685	–0.743	–0.717	–0.698	–0.718
	Sensible Load Removal	kW	–2.203	–1.861	–1.329	–2.640	–2.087	–2.904
	Latent Load Removal	kW	1.496	1.176	0.586	1.923	1.389	2.185
	Condensate Production	pints/day	96.85	80.62	55.24	123.42	98.73	143.7
	Efficiency	liters/kWh	3.023	2.377	1.435	3.584	2.662	3.912
Model	Electric Power (Model)	kW	0.661	0.693	0.791	0.711	0.770	0.755
Model	Total Load Removal (Model)	kW	–0.707	–0.689	–0.739	–0.710	–0.705	–0.715
Model	Sensible Load Removal (Model)	kW	–2.197	–1.843	–1.327	–2.682	–2.103	–2.897
Model	Latent Load Removal (Model)	kW	1.491	1.154	0.588	1.972	1.397	2.183
Model	Condensate Production (Model)	pints/day	95.4	81.1	54.3	126.2	100.7	142.6
Model	Efficiency (Model)	liters/kWh	2.984	2.401	1.415	3.648	2.690	3.878
Model	Electric Power Error	kW	0.001 (0.2%)	–0.005 (0.7%)	–0.001 (0.12%)	0.003 (0.41%)	0.007 (0.95%)	–0.001 (0.08%)
Model	Total Load Removal Error	kW	0 (0%)	–0.004 (0.53%)	0.004 (0.6%)	0.007 (0.93%)	–0.007 (1.02%)	0.003 (0.47%)
Model	Sensible Load Removal Error	kW	0.005 (0.25%)	0.018 (0.94%)	0.002 (0.15%)	–0.042 (1.59%)	–0.015 (0.73%)	0.006 (0.22%)
Model	Latent Load Removal Error	kW	–0.005 (0.36%)	–0.021 (1.79%)	0.003 (0.43%)	0.049 (2.54%)	0.008 (0.59%)	–0.003 (0.13%)
Model	Condensate Production Error	pints/day	–1.433 (1.48%)	0.447 (0.55%)	–0.894 (1.62%)	2.795 (2.26%)	1.929 (1.95%)	–1.095 (0.76%)
Model	Efficiency Error	liters/kWh	–0.039 (1.29%)	0.024 (1.02%)	–0.02 (1.4%)	0.064 (1.78%)	0.028 (1.06%)	–0.034 (0.87%)

Table 5. Summary of Test Data (continued)

	Unit	2a	8a	9a	13a	14a	15a
Test Duration	Hours	0.497	0.465	0.231	0.483	0.499	0.350
T_In	deg_C	29.40	21.10	32.20	26.71	32.21	26.75
T_Out	deg_C	41.73	38.31	45.34	42.28	47.50	47.46
T_condensate	deg_C	12.54	11.81	14.97	13.94	16.92	23.63
Tdew_In	deg_C	15.45	17.46	17.65	18.20	20.32	25.04
Tdew_Out	deg_C	11.17	11.04	13.55	13.03	16.02	19.99
W_In	kg/kg	1.37E-02	1.57E-02	1.58E-02	1.63E-02	1.87E-02	2.50E-02
W_Out	kg/kg	1.03E-02	1.02E-02	1.21E-02	1.16E-02	1.41E-02	1.82E-02
W_In	grains	96.00	109.54	110.82	114.26	130.67	175.00
W_Out	grains	72.21	71.65	84.75	81.43	99.03	127.39
Delta_grains	grains	23.79	37.91	26.10	32.83	31.64	47.61
P_ambient	Pa	81371	81307	81342	81765	81894	82211
P_In	Pa	81372	81308	81343	81763	81892	82209
P_Out	Pa	81370	81307	81340	81768	81897	82213
Air flow_In	SCFM	327.9	328.1	329.8	327.5	327.2	335.9
Air flow_Out	SCFM	327.0	328.2	329.2	327.2	327.1	336.0
Flow_Condensate (Coriolis)	kg/sec	6.46E-04	8.81E-04	6.80E-04	8.41E-04	8.49E-04	1.19E-03
Flow_Condensate (Coriolis)	gpm	1.03E-02	1.40E-02	1.08E-02	1.34E-02	1.35E-02	1.90E-02
Total Condensate Weight (Scale)	lbs	2.59	3.50	2.81	3.31	3.31	3.44
Total Condensate Weight (Coriolis)	lbs	2.554	3.262	1.251	3.231	3.373	3.325
Total Condensate Weight (Coriolis)	kg	1.159	1.480	0.568	1.465	1.530	1.508
Balance_AirMass	Unitless	1.003	1.000	1.002	1.001	1.000	1.000
Balance_MoistureMass	Unitless	0.997	1.046	1.007	1.011	0.997	1.022
Balance_Energy	Unitless	1.004	0.997	1.005	1.000	1.001	0.996

Electric Power	kW	0.820	0.779	0.874	0.831	0.907	0.916
Total Load Removal	kW	–0.731	–0.716	–0.736	–0.744	–0.776	–0.788
Sensible Load Removal	kW	–2.318	–3.240	–2.486	–2.927	–2.875	–3.997
Latent Load Removal	kW	1.587	2.524	1.750	2.183	2.098	3.209
Condensate Production	pints/day	118.4	161.3	124.8	154.2	155.7	219.2
Efficiency	liters/kWh	2.967	4.257	2.936	3.814	3.525	4.910

Model	Electric Power (Model)	kW	0.821	0.775	0.873	0.828	0.905	0.918
	Total Load Removal (Model)	kW	–0.726	–0.728	–0.753	–0.730	–0.768	–0.790
	Sensible Load Removal (Model)	kW	–2.336	–3.203	–2.478	–2.922	–2.867	–4.009
	Latent Load Removal (Model)	kW	1.610	2.476	1.725	2.192	2.099	3.220
	Condensate Production (Model)	pints/day	117.1	160.9	128.4	151.4	153.8	220.2
	Efficiency (Model)	liters/kWh	2.937	4.259	3.024	3.754	3.483	4.930
	Electric Power Error	kW	0.001 (0.16%)	–0.004 (0.48%)	0 (0.05%)	–0.003 (0.35%)	–0.002 (0.18%)	0.002 (0.25%)
	Total Load Removal Error	kW	0.005 (0.66%)	–0.012 (1.65%)	–0.017 (2.36%)	0.014 (1.86%)	0.009 (1.1%)	–0.002 (0.24%)
	Sensible Load Removal Error	kW	–0.018 (0.77%)	0.037 (1.14%)	0.008 (0.31%)	0.004 (0.15%)	0.008 (0.27%)	–0.013 (0.31%)
	Latent Load Removal Error	kW	0.023 (1.44%)	–0.049 (1.93%)	–0.025 (1.43%)	0.01 (0.44%)	0.001 (0.05%)	0.011 (0.34%)
	Condensate Production Error	pints/day	–1.23 (1.04%)	–0.485 (0.3%)	3.522 (2.82%)	–2.774 (1.8%)	–1.822 (1.17%)	1.043 (0.48%)
	Efficiency Error	liters/kWh	–0.029 (1.03%)	0.002 (0.05%)	0.088 (2.99%)	–0.06 (1.58%)	–0.042 (1.18%)	0.02 (0.4%)

Appendix B – Photos of Experimental Setup

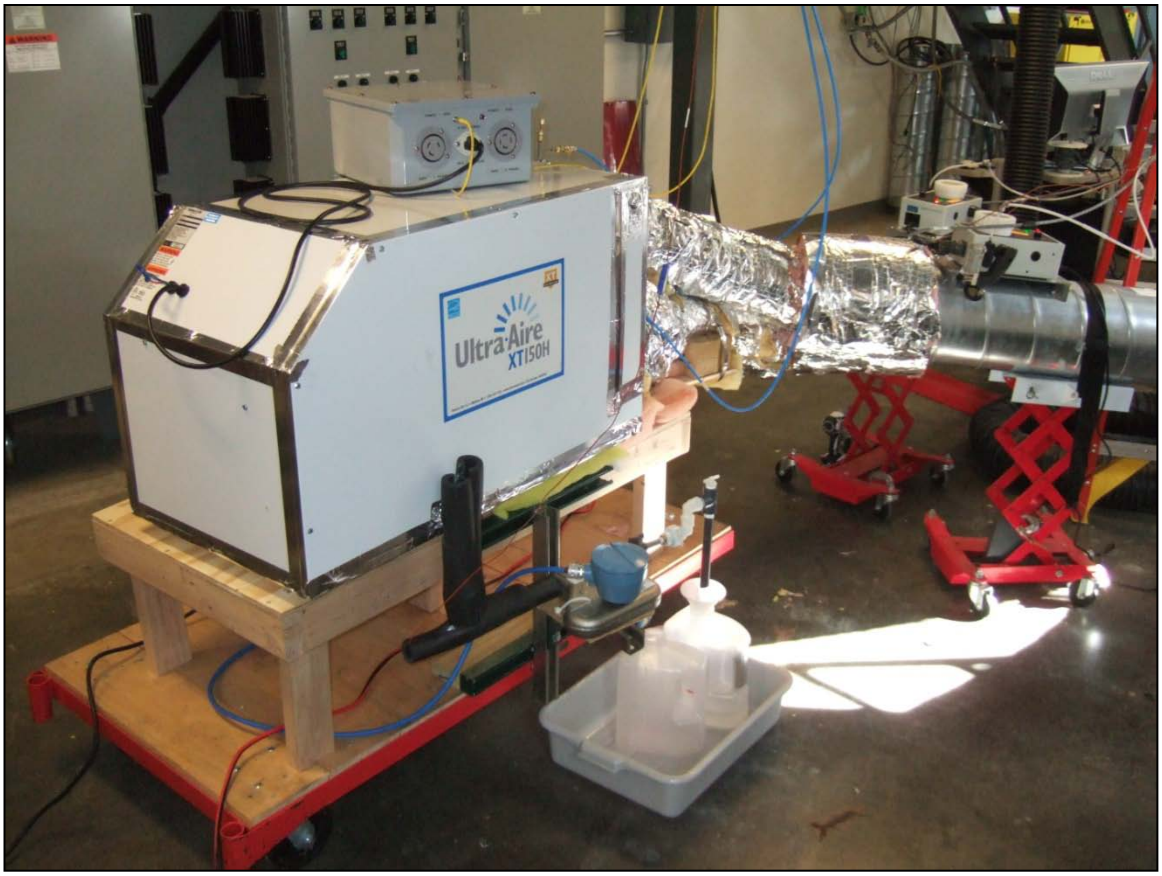


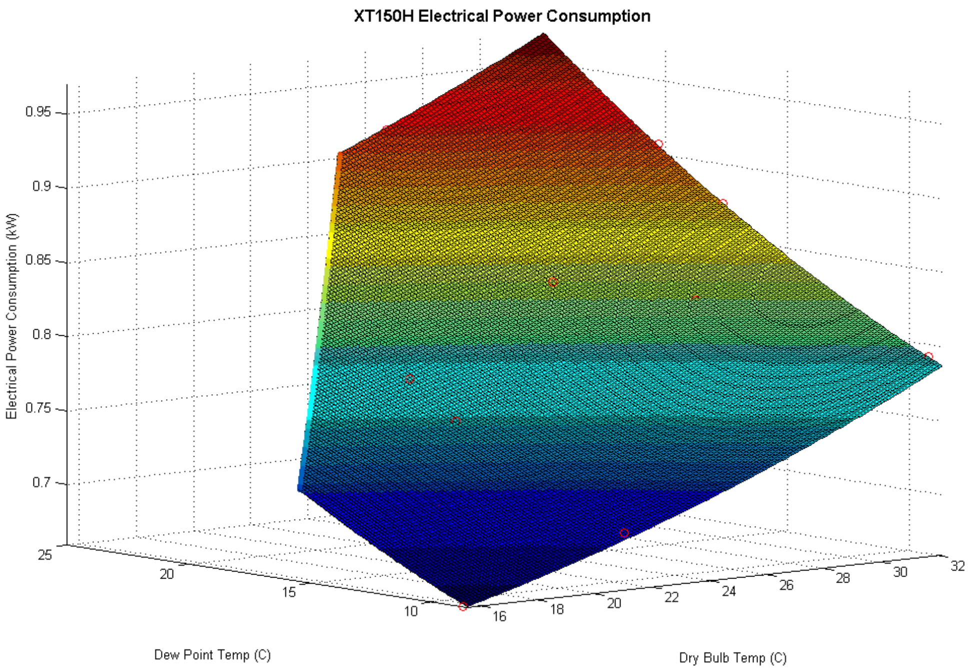
Figure 5. Photograph of Ultra-Aire XT150H test setup

A stand was constructed to elevate the unit so flow could be measured and collected. The temperature of the flowing condensate was measured in the trap. This piping was insulated to maintain condensate temperature up to a coriolis flowmeter. The condensate was collected downstream in the jug seen in the lower center of the image, and weighed after the test. All seams in the XT150H's sheet metal box were sealed with aluminum tape, to prevent air leakage and thus maintain an accurate air mass balance. The gray box sitting on top of the dehumidifier is the power meter.

Figure 6. Photograph of Ultra-Aire XT150H test setup

The rigid ductwork to the right of the image is a mixing section, at the end of which temperature and humidity are measured. Thick insulation was applied to the ductwork after that measurement to prevent heat loss and condensation prior to the dehumidifier inlet. Similarly, insulated ductwork routes the outlet airstream to a mixing section where outlet temperature and humidity are measured. The inset image shows pitot tube connections for pressure measurement immediately at the unit's inlet and outlet. The blue tubing connects the pitot tubes to pressure transducers.

Appendix C – Plots of Data Fit Surfaces and Model Comparisons



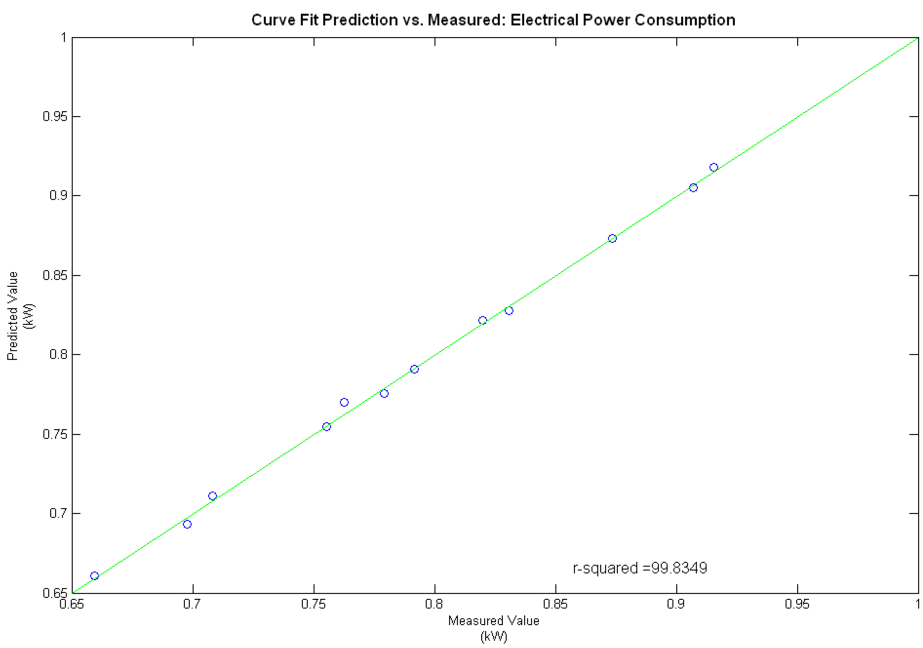
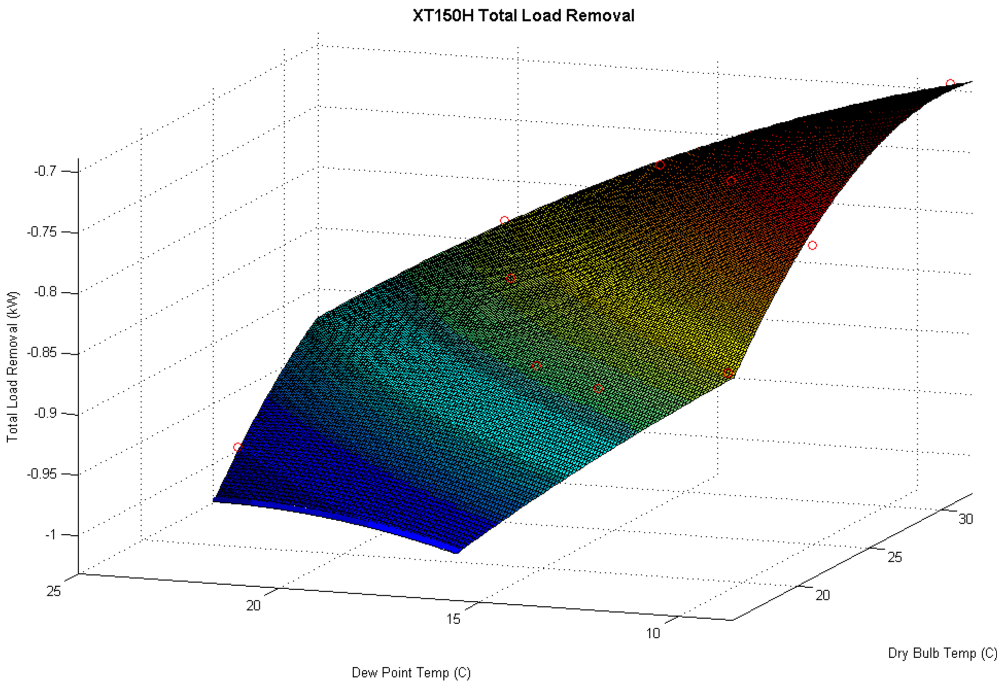


Figure 7. Electrical power consumption (kW)



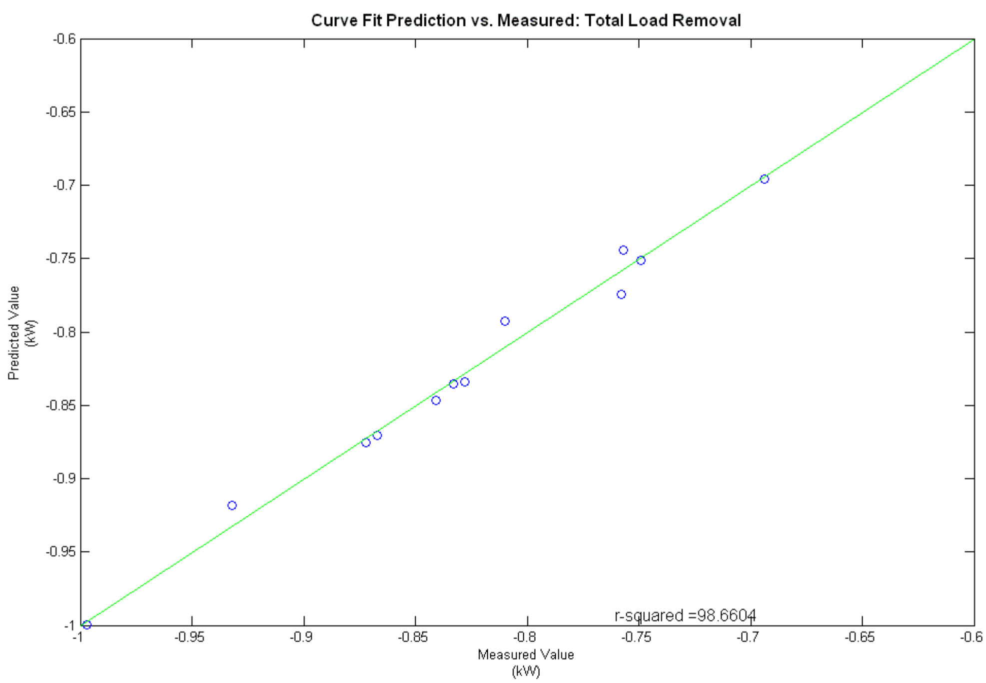
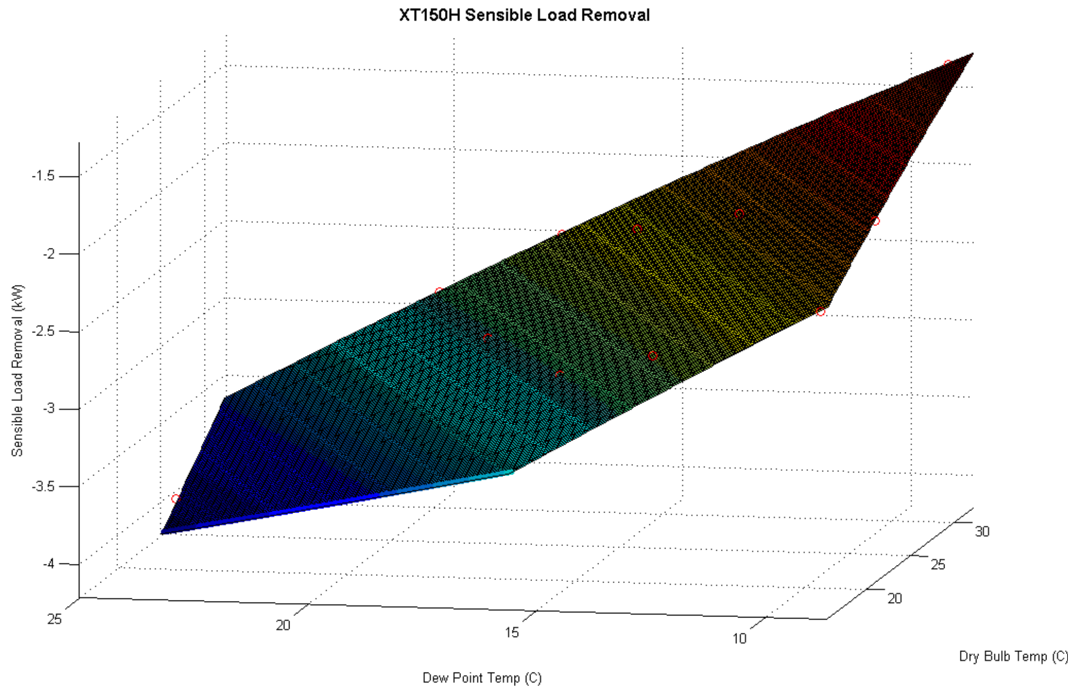


Figure 8. Total load removal (kW)



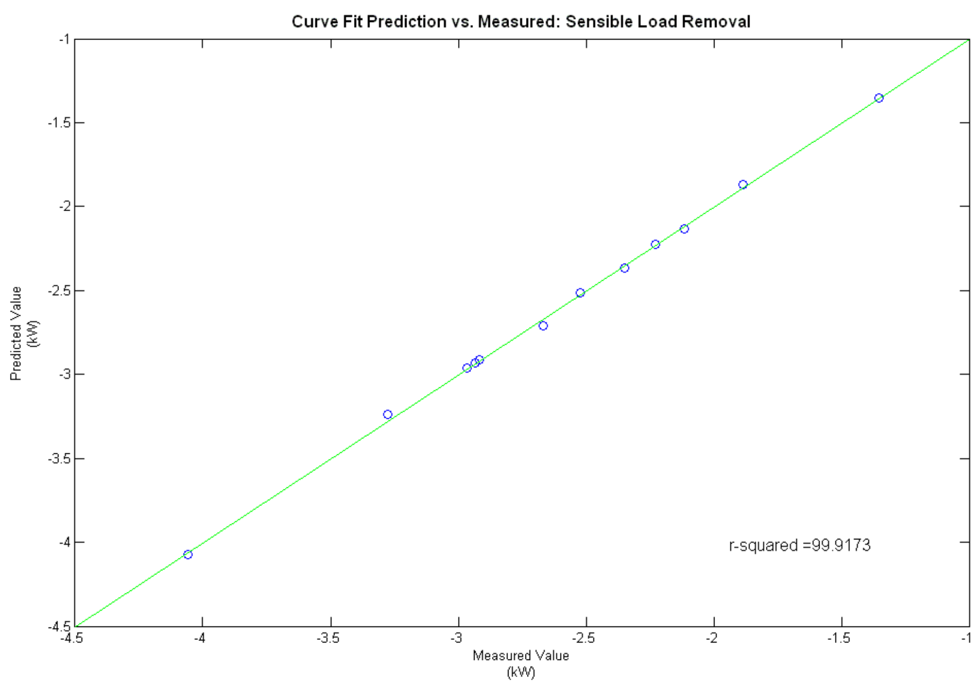
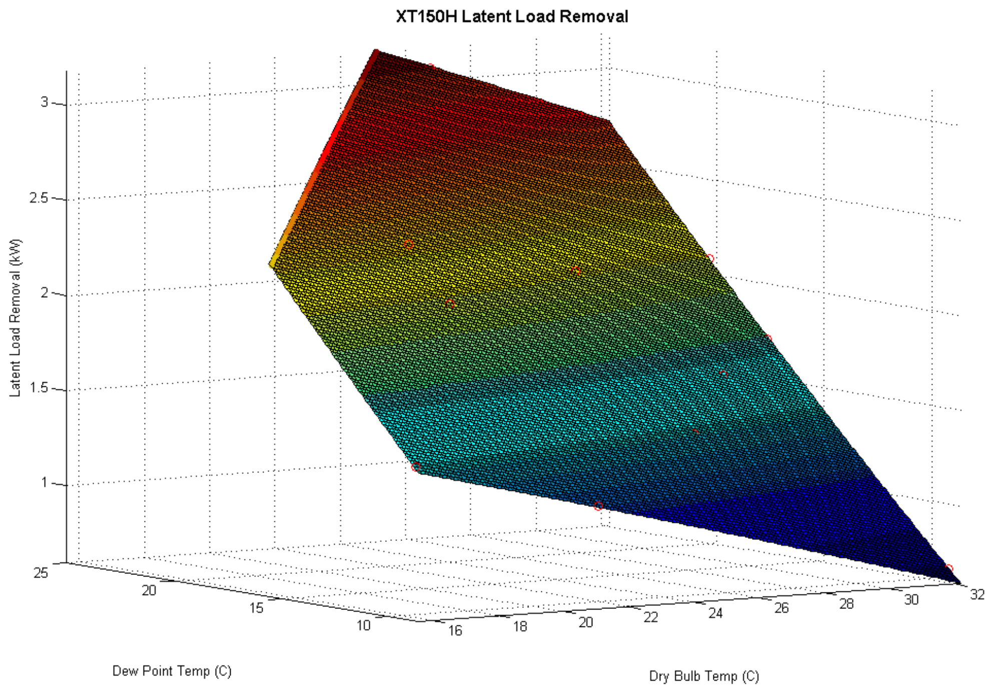


Figure 9. Sensible load removal (kW)



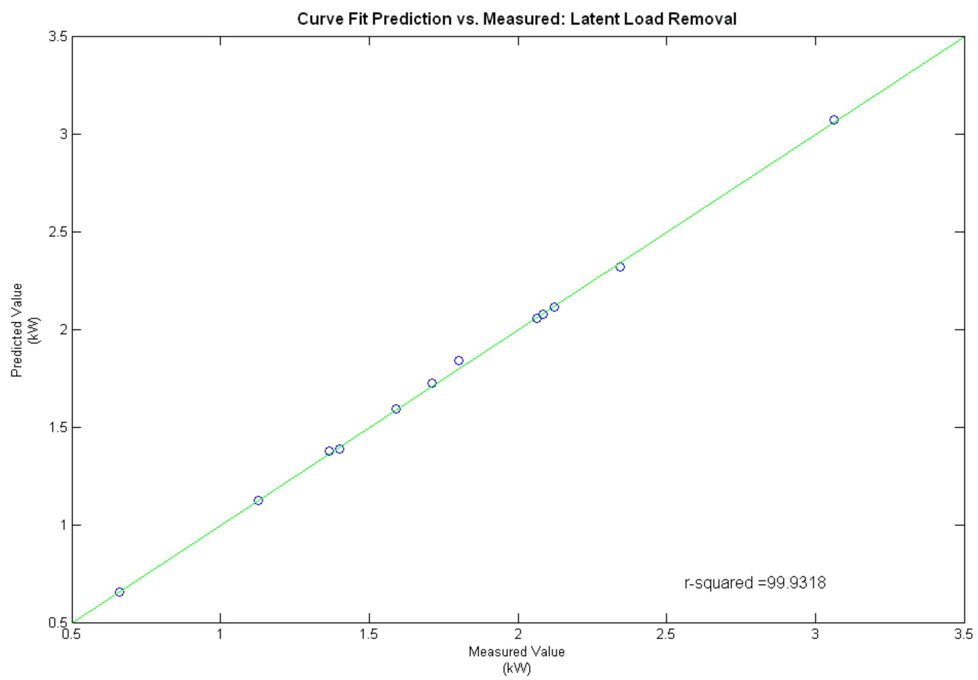
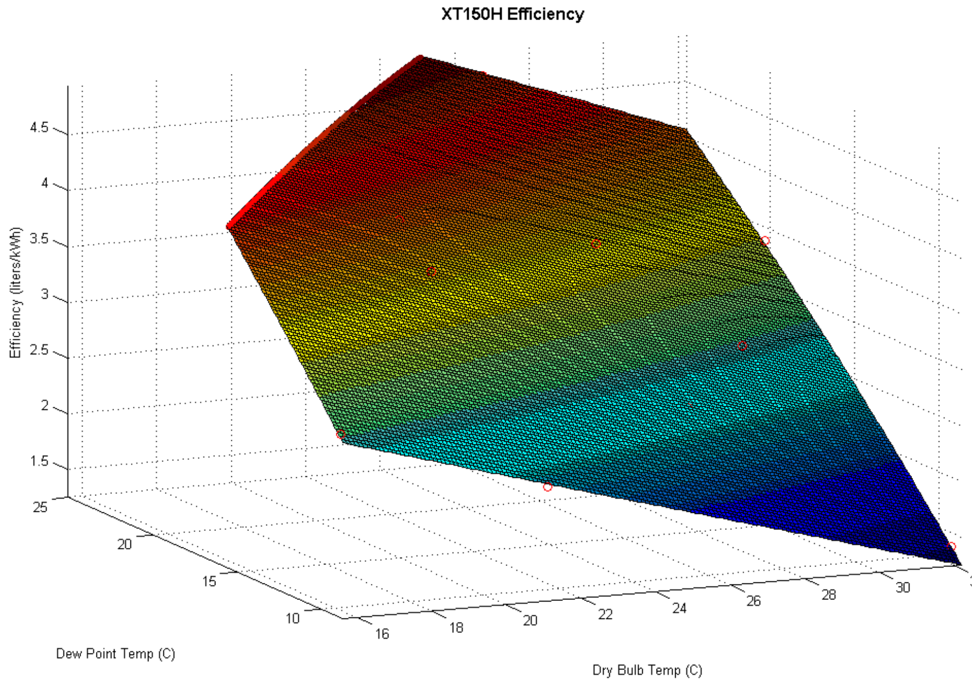


Figure 10. Latent load removal (kW)



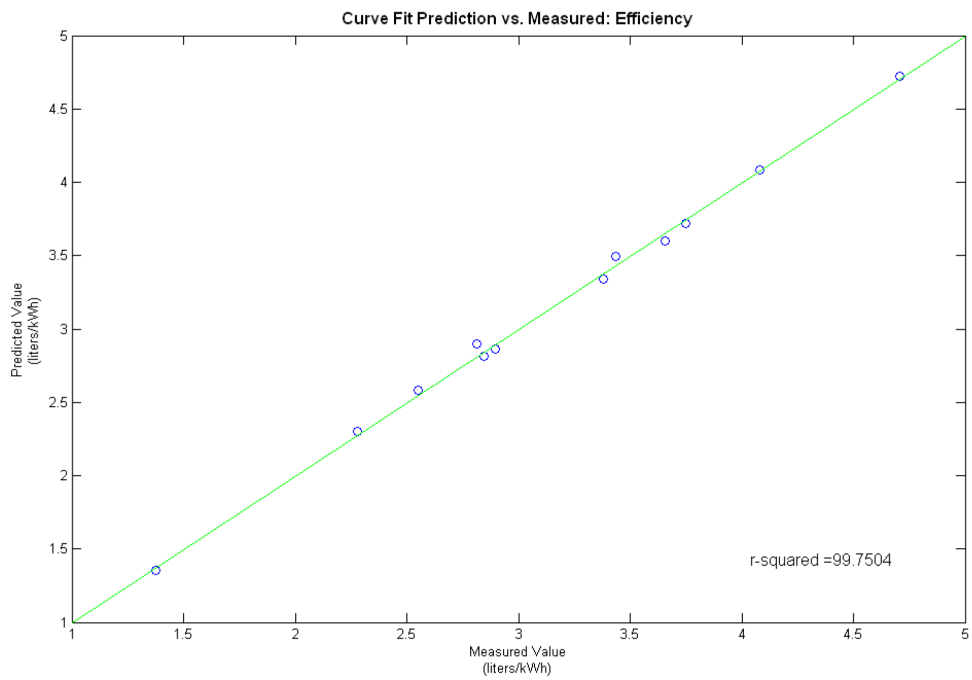
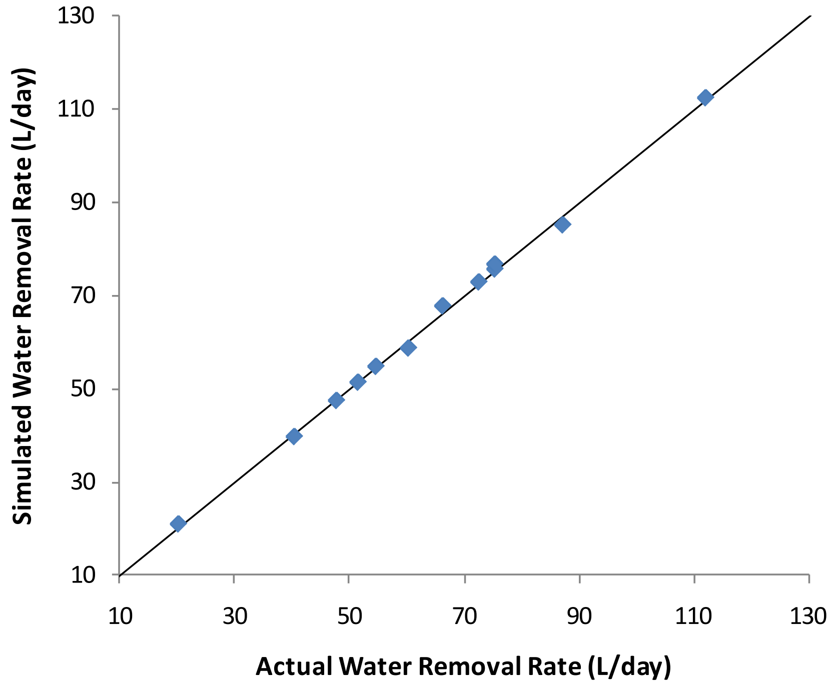


Figure 11. Efficiency (L/kWh)

Appendix D – Plots of EnergyPlus Model Performance Comparisons



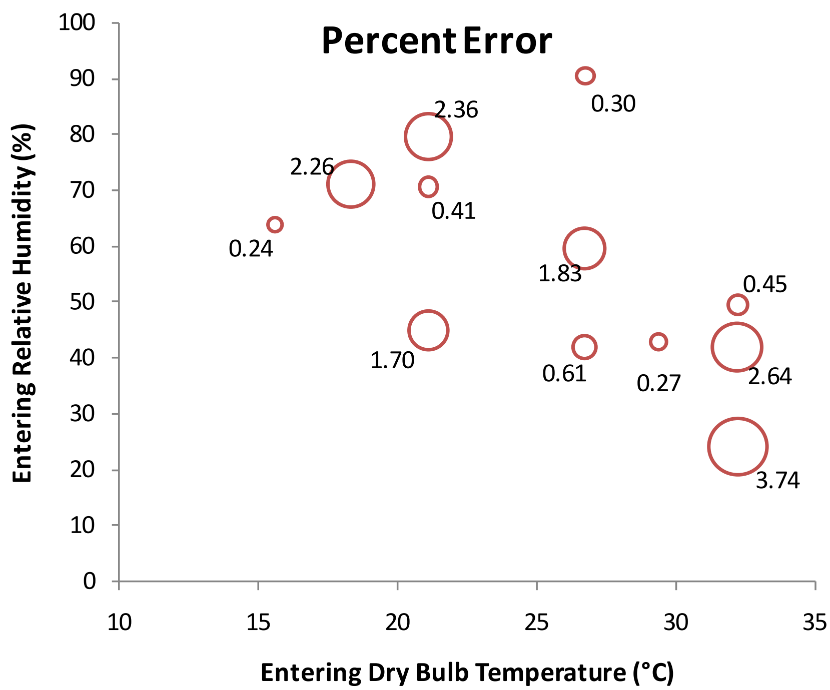


Figure 12. EnergyPlus Model – Water Removal Rate (L/day)

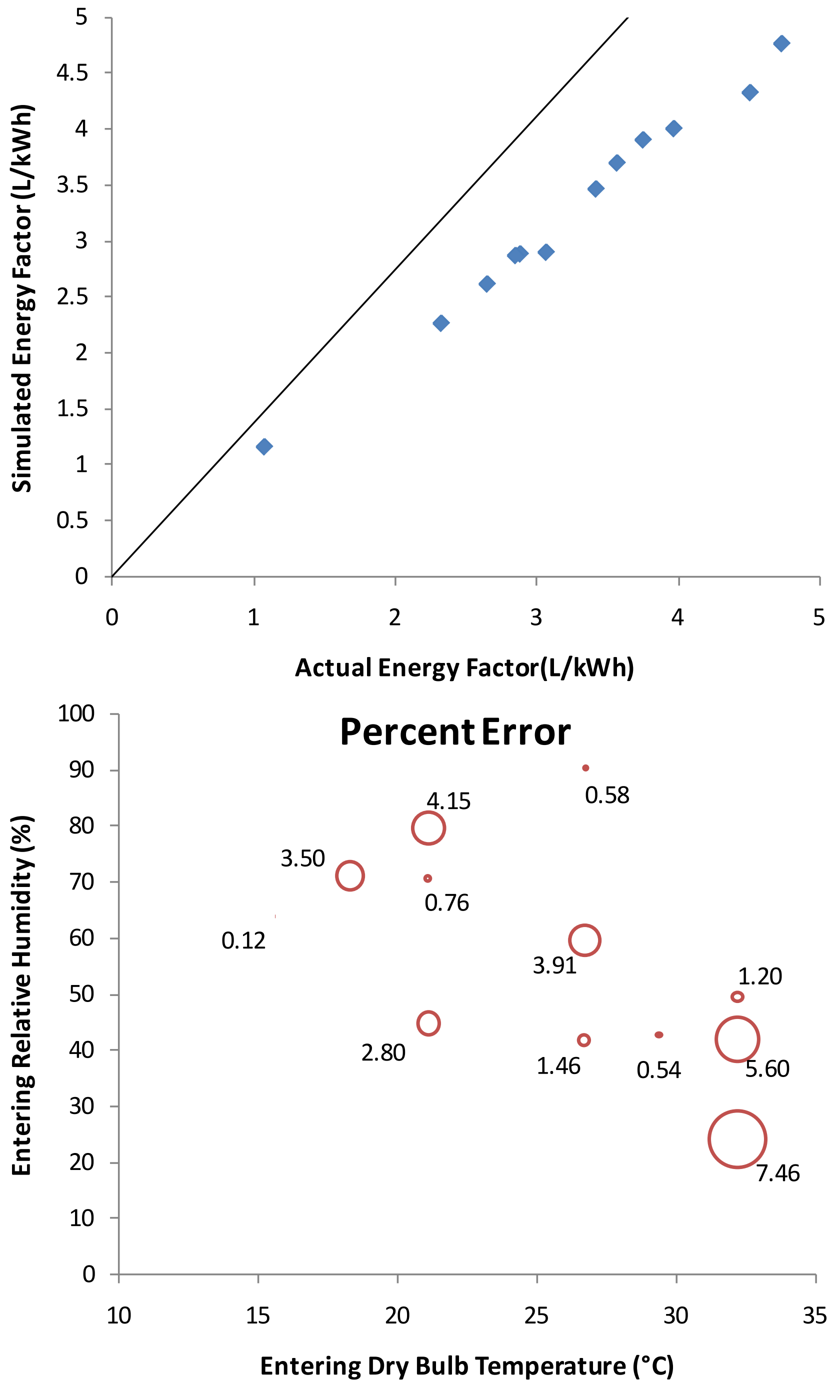


Figure 13. EnergyPlus Model – Energy Factor (L/kWh)

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14. ABSTRACT *(Maximum 200 Words)*
This report documents the measured performance of the ThermaStor Ultra-Aire XT150H Dehumidifier. The equipment is an ENERGY STAR® vapor-compression cycle whole-house unit. Its performance was measured across a wide range of inlet air conditions and fit to a numerical model with R-squared values greater than 0.998 for electrical power consumption, sensible and latent load removal. The numerical fit was then used to implement the Zone Air Direct-Expansion Dehumidifier performance model in EnergyPlus.

15. SUBJECT TERMS
thermastor; thermastor ultra-aire; ultra-aire; xt150h; dehumidifier

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